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DESIGN AND DEVELOPMENT OF AN IMMERSIVE SIMULATION FOR SOCIAL
DETERMINANTS OF HEALTH TRAINING

A Thesis submitted in partial fulfillment of the
requirements for the degree of
Master of Science

by

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B. Tech., Kakatiya University, India, 2017

2019

Wright State University

WRIGHT STATE UNIVERSITY

GRADUATE SCHOOL

December 13, 2019

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Lahari Surapaneni ENTITLED Design and Development of an Immersive Simulation for Social Determinants of Health Training BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science.

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ABSTRACT

Surapaneni, Lahari. M.S. Department of Computer Science and Engineering, Wright State University, 2019. Design and Development of an Immersive Simulation for Social Determinants of Health Training.

This thesis research project focuses on design and development of an immersion simulation-based training tool that help raise the social determinants of health (SDOH) awareness among the health care providers. Compared to existing classroom lecture and/or role-play based SDOH education approach, our immersion-simulation based approach provides an easy access and highly realistic experience to such training curriculum at anytime and anywhere with an Internet connection. Such an interactive and immersive exposure is critical to raise SDOH awareness and maintain long-lasting empathy towards actual patients in practice, and thus help providers to be better prepared when encountering with those patients.

Particularly, this thesis has contributed to the first mobile virtual immersion dedicated for SDOH training. We take advantage of the latest advances in mobile VR technologies to create the new SDOH training mobile game that is made available for both tablets and smartphone devices. It presents specifically such Social determinants of health as numerous adverse childhood experiences (ACEs), SUD, race and ethnicity, unemployment, and single mothers. A preliminary validation was carried out to assess its acceptance and effectiveness as a training tool. Early evidences from the collected data show that this simulation is an effective learning platform that helps providers: 1) decrease any negative biases toward patients; and, 2) be a more understanding health professional.

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1. INTRODUCTION

The objective of this research project is to develop a training tool that help raise the social determinants of health awareness among the health care providers, e.g., doctors, nurses, medical assistants, social workers, receptionists, administrative personnel's and other health care professionals. The social determinants of health are the various factors that affect the health of a person. Some of those factors are: where the patient is born and brought up, education, financial situation, age, culture, social support and many [1].

There is a popular proverb "Health is wealth". Staying healthy is essential for people to pursue a happy living. People with limited income and resources are facing challenges in their health and their access to enough health care compared to others due to social and economic circumstances [2]. Some groups of people, particularly racial and ethnic minorities, often experience higher risks to become under-resourced. Medicaid in the United States is a federal and state program that helps with medical services for these people [3][4]. It has served as the nation's primary source of health insurance coverage for low-income populations.

However, it remains a challenge to provide consistent and high-quality care for patients as every patient is unique. The best treatment and care come out from accurate diagnosis that may often go beyond what the collected data charts can tell. Clinic encounter with the patient is critical to obtain a more comprehensive understanding of the health issues that the patient is facing. Awareness about the patient's background often helps providers carry out the dialogue more effectively and efficiently, particularly when the clinical encounter is extremely limited in time.

Unfortunately, it is difficult for anyone to fully understand the needs and challenges faced by another person that possibly live a very different life. Even the healthcare professionals may show bias towards different patient groups when they are not aware about the patient's struggles which are beyond their control. For instance, when a patient is late for his/her appointment, the provider could assume the patient didn't take the appointment responsibly and respectfully. But the awareness of the patient's difficulty for transportation may help raise the provider's acceptance in such situation. As a result, we believe giving the providers exposure to the patient's experience is critical to raise such awareness and help providers to be prepared when encountering with patients.

There are many approaches to train the providers with SDOH. For example, it can be given in groups through lectures or individually through the expert-guided role-play session. The above approaches are common ways to train and spread the SDOH awareness, but there are limitations. When it is taught in person, it takes time and is often cost-prohibitive to reach most providers, particularly as refresh training for providers already in practice. On the other hand, teaching in class approach often stops short in providing the necessary practice to apprehend the impacts of SDOH through the first-person experience. As a result, we believe there is an urgent need for a new training approach that can conveniently engage the providers, in the first-person view, with the patient's experience.

All these factors have motivated me to propose a VR game-like experience to give the providers the exposure of the social determinants of health perspective. Taking into consideration the vast availability of mobile smartphones and tablets, I also believe Mobile VR is the right choice to deliver this training game. Thus, in this thesis research, we proposed to harness the latest advances in mobile VR technologies to create a new SDOH training tool. We have designed and developed a mobile VR game, so that the trainees may be able to go through the game whenever they have time and wherever they feel like it.

This way we can expose to the providers/doctors with realistic experience anytime and anywhere with an Internet connection.

2. LITERATURE REVIEW

Virtual Reality (VR) has been used for games and other scientific and professional trainings. It has been used in the medical field as well. I also believe that using VR immersion simulation can also help the doctor with the social determinants of health awareness.

Unfortunately, there are very few applications on addressing the Medicaid issues and challenges, and we are not able to find any mobile VR applications, in either Apple App store or Google Play Store, that is dedicated to help the providers in mitigating the bias in their practices. As a result, we believe this mobile application will be among the very few medical apps that address the issues/problems that are prevailing in the society, and it is the only known app that is dedicated to training the doctors on eliminating the bias towards different socio-economic groups, e.g., racial and ethnic minorities, especially in the healthcare domain. Based on this survey, clearly, there is a need for training the Medicaid providers using a highly interactive mobile VR game. Furthermore, to be effective to stimulate the empathy of the trainees, the characters and interactions presented in the game must appear highly realistic such that the emotions can be felt and understood.

3. SYSTEM DESIGN AND DEVELOPMENT

The objective of this thesis research is to develop a virtual simulation featuring the health center visit of a pregnant African-American female patient with a history of opioid use disorder. The VR immersion includes four scenes of the visit: 1) preparation for and transportation to the appointment (from the perspective of the patient); 2) check-in at the health center's front desk (from the perspective of the patient); 3) encounter between the clinician/provider and the patient (from the perspective of the provider); and 4) encounter between a social worker and the patient (from the perspective of the patient).

Social determinants of health presented in this case include numerous adverse childhood experiences (ACEs), SUD, race and ethnicity, unemployment, and single mothers. These SDOH are first presented to the trainee through a customized case of Life Course Game that originated from the CDC. This work focuses on the immersion that follows. It intends to emphasize barriers experienced by the patient that are the result of social determinants and/or biases on the part of others.

3.1. Story Design

This project's story is about Ebony, an African-American woman who is 31-year-old and with a history of opioid use disorder. She is a single mom. She got into an accident four years ago in which her lower leg was crushed. The pain due to the crush is being controlled, all these years, using opioids that were prescribed to her by her old doctor. Ebony recently broke up with her boyfriend and now doubts if she is pregnant.

3.1.1. The motivation of the Story Design

There is a proverb "Health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity". Many factors influence our health. Some of the important factors that determine our health is:

- 1) Social environment
- 2) Economic environment
- 3) Physical environment
- 4) The individual's behavior and characteristics.

The use of healthcare services is to prevent and/or cure health problems, promote health, prevent unnecessary disabilities and many. As mentioned above,

Ebony has been using the opioid painkiller for four years now. It is not her own decision to use the substance. Studies have shown many patients take opioid painkillers as prescribed by the doctors and later develop an opioid dependency [5-7]. Unfortunately, when she visits the healthcare center, the providers may assume it is all her fault and show bias when encountering her and treat her health issues.

If substance usage is one problem here, the other problem is her being an African-American. The amount of care that the healthcare professionals show towards the minorities may not be the same level as they treat the other groups. So, there are chances that the healthcare providers listen to only half of the patient's story and prescribe the meds. This results in increasing health disparities, lowering patient care quality in general [8]. When there is not sufficient quality in the services, it only contradicts the mission of healthcare professionals and the Medicaid programs.

Coming to the next factor, Ebony as a single mom. Being a single mom surely isn't an easy task. Doing everything on her own is very difficult, especially when she is becoming pregnant again. A pregnant woman has to be extra careful to

avoid any harm to the health of the baby and herself. Now, Ebony needs to work to make her living as well as take care of her pregnancy. We can clearly understand that Ebony is experiencing a potentially excessive amount of stress from many sources: emotionally from the breakup with a boyfriend, physically from the leg pain, financially due to limited income, etc.

Unfortunately, it is not uncommon at all to have a patient just like Ebony in the real-world. We want to add to her story a few positive components: her grandma who helps, and a friend who is willing to help even with her own challenge. As a result, we want to present her story in this SDOH training.



Figure 1: Ebony being a single mom

3.1.2. The Storyline

The game starts with Ebony waiting for her friend, Mary, to pick her up to go to the healthcare center. Ebony had a choice of using public transport, but since she was in pain and possibly became pregnant, she wanted someone to come along with her to the hospital, for emotional support. She initially asked a couple of her

other friends but unfortunately, they aren't available to give Ebony a ride to her appointment.

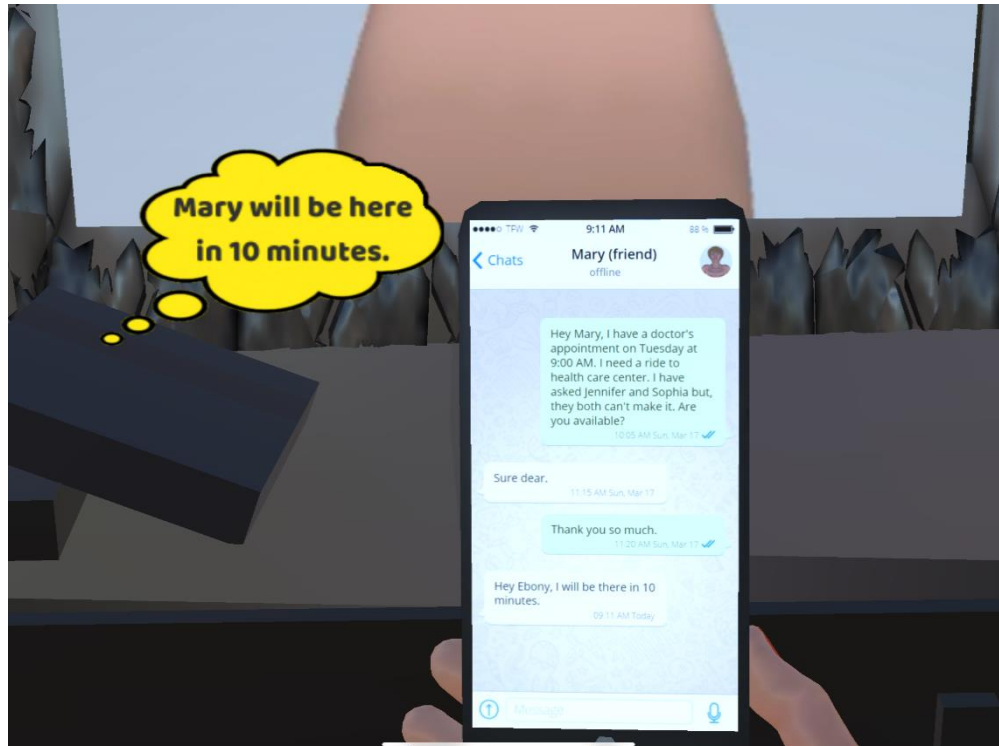


Figure 2: Ebony trying to get a ride to the healthcare center

Mary comes to her house to pick her up but about half an hour late and finally, get on their way to the healthcare center. In the car, Mary tries to explain to Ebony why she was late. Mary had to find someone to watch her kids but tried her best to come as fast as she could. Ebony is worried if she could meet with the doctor as she is already 30 minutes late.

Then at the healthcare center, we try to emulate the routines taking place there. The receptionist work with her to sign her in. A medical assistant leads her to the exam room and gives her a cup for the urine sample test. After Ebony is done with the test, she is asked to wait for the doctor. Meanwhile, the MA gives the doctor a little information about Ebony's case.



Figure 3: Medical Assistant giving case details to the doctor/healthcare professional

Then, by switching to the view of the doctor, we emulate the clinic encountering. The doctor comes into the room and checks the EHR. Then she starts the dialogue with Ebony. The player, in the role of doctor, take control of the process, and make choices on how to proceed to carry out the conversation with the

patient to find out, e.g., why Ebony had to use opioid, how she feels about her pregnancy, what she thinks is good for her and so on.

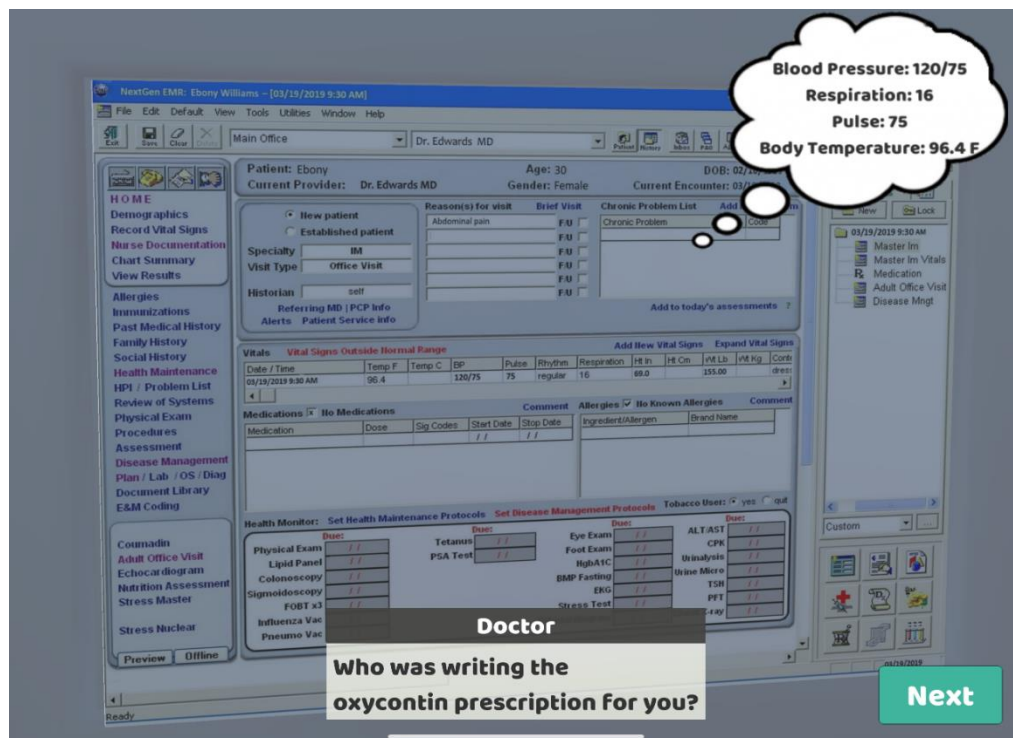


Figure 4: Doctor checking Ebony details

Through the interactive game, Ebony then explains her situation where she was involved in a car accident four years ago in which her lower leg was crushed for which her old doctor had prescribed opioid painkillers. Ebony has been using these opioids for a very long time that she has become dependent on them. If she continues to use opioids, it might affect her pregnancy which she doesn't want to

happen. She also tells the doctor that she has recently broken up with her boyfriend and that she wants to take care of her baby without any harm. The doctor explores with her other options to control the pain more safely. They agree to seek Medication-assisted treatment (MAT). But Ebony has to be transferred to another clinic that is authorized for the new treatment.

Finally, comes the social worker named Sabrina. The view is switched back to the patient's view. Social workers are the professionals who evaluate a patient's emotional, environmental financial and social circumstances and needs and help him in providing training, resources and more. Sabrina tells Ebony that she is glad that Ebony has taken a step forward and consulted a doctor about her problem. Since this healthcare center doesn't have MAT service available, she is helping Ebony to locate such a service provider. Hence, she calls a few places where they eventually can find the earliest slot available.

3.1.3. The Story Scenes

The whole story is organized in four scenes:

1) preparation for and transportation to the appointment (from the perspective of the patient);

2) check-in at the health center's front desk (from the perspective of the patient);

3) encountering between the clinician/provider and the patient (from the perspective of the provider); and,

4) encountering between a social worker and the patient (from the perspective of the patient).

There are also three different places:

1. Apartment



Figure 5: Ebony's apartment

2. Street



Figure 6: Street

3. Clinic



Figure 7: Receptionist in Clinic



Figure 8: Exam room in Clinic

To implement the above story, there are a few challenges that have to be addressed by computer science knowledge and expertise. The biggest challenge is the time limit, the whole story must be completed in around 15-20 minutes. Otherwise, the users may lose interest or may simply not have time to complete the game.

To limit the game time to its minimum, there are some places in the game where we need to adjust the scripts. For example, we have mentioned for the transportation that Ebony has asked a couple of other friends to give her a ride to the hospital. Later her friend Mary comes and rings the doorbell and Ebony attends the door. All this needs to be shown in less than a minute. Hence, we have used

mobile as a prop and through mobile chatting is how we have conveyed to the users that she has made every effort to secure her transportation to the health center: already contacted two other friends of hers and that they are not free to give her a ride. In that chat image, Ebony will be explaining to Mary about all this.

Another example is, to show that Ebony when she is in the house, is worried about her pregnancy. This is shown using her facial expressions and body gestures, like her hand on her tummy and slightly rubbing it, by looking at herself in the mirror.



Figure 9: Ebony worried about her pregnancy

3.2. Character Design

From the story, there are many characters that are involved and interact with each other. There is a reason for each character's presence in the game. In addition to the patient herself, we also created Mary as her friend in her social support circle. To realistically emulate the clinic encounter at a community healthcare center, we have included professionals like receptionist, MA, doctor and social workers. Additional patients are created and shown in the background as well. The list of all the characters is:

1. Patient (Ebony)



Figure 10: Patient (Ebony)

2. Patient's friend (Mary)



Figure 11: Patient's Friend (Mary)

3. Receptionist (Mary Cox)



Figure 12: Receptionist (Mary Cox)

4. Medical Assistant (Blaine King)

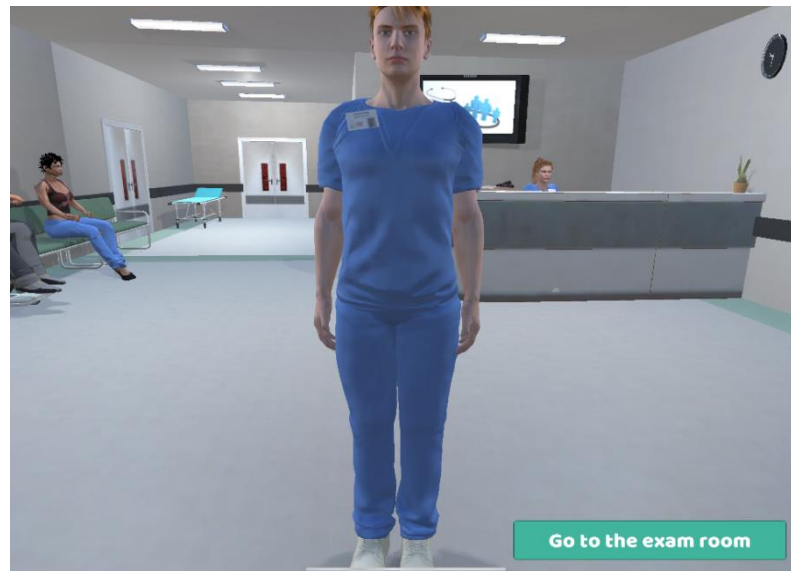


Figure 13: Medical Assistant (Blaine King)

5. Doctor (Dr. Edwards)



Figure 14: Doctor (Dr. Edwards)

6. Social Worker (Sabrina)



Figure 15: Social Worker (Sabrina)

3.2.1. Challenges for Character Design

High-quality virtual character is critical to stimulate the expected response/empathy from trainees. However, this requires a large number of polygons to produce such a character. The challenge for smartphone and tablet devices is they have limited rendering speed. This simulation requires multiple characters, but mobile devices limit the app size due to memory limitations.

To address those challenges, we take an iterative and differentiate approach to deal with the quality and rendering speed limitations.

In computer graphics, the base of the body, the clothes or any accessory is made up of Mesh. This mesh is composed of polygons which are triangles. The more the number of triangles, the higher the quality of the character. However, if the quality is higher, the size of the file is also bigger. Clearly, there is a tradeoff to be considered in our design. This is particularly true when the resource-limited mobile devices are used as the primary delivery platforms. The challenge here is to find the right balance. If we put the quality too high, the file sizes will be too big to accommodate them in the mobile game. The game has a limit as to how much space it can take. Lowering the mesh on the other side might result in a poor quality of the character. It might also affect the animation which may become annoying during the game. Moreover, there are several characters in the game that need to be accommodated.

Using an iterative approach, we have first used the commercial tool called Character Creator and then go through the following steps after importing the character into Unity in order to reach a balance between quality and rendering speed by making sure the graphic runs smoothly:

- 1) Adjust the character quality in Unity 3D using the Mesh Simplifier Script
- 2) Build the mobile app using the updated character
- 3) Install and test in a tablet device. Alternatively, the Unity Remote can be used to speed up the process to avoid Step 2 and 3.

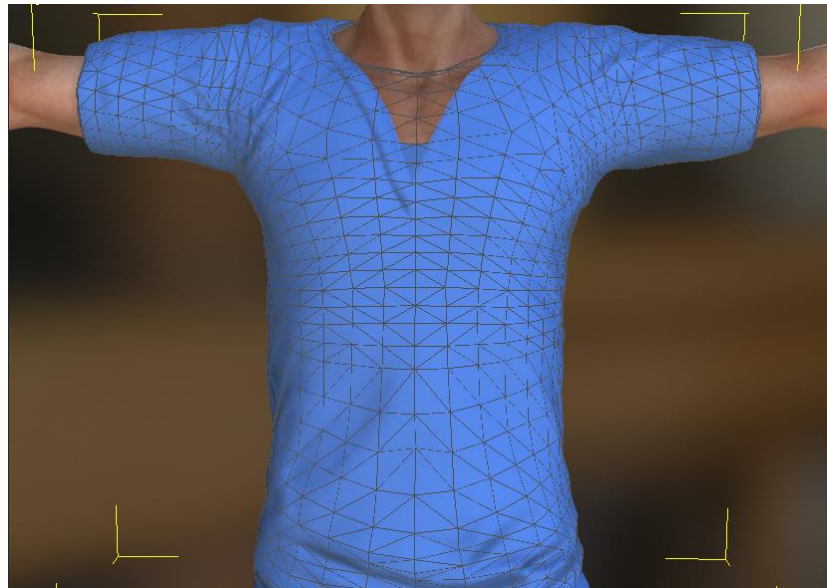


Figure 16: High-quality character



Figure17: Low-quality character

In order to limit the app size, we also take a differentiated approach: the main characters are of high quality while background characters have reduced quality. As a result, we can convey the message without losing quality even when using a resource-limited mobile device.



Figure 18: Main Character (High quality)



Figure 19: Background Character (Low quality)

The computer graphic depiction of the main characters must be realistic. This helps the trainees feel more relatable and find the game more engaging. Ultimately, we believe it helps in improving the learning outcomes.

Thus, all these characters are created using a commercial tool called Character Creator [9], a product of Reallusion Software. We can create and customize the body and clothes of each character using this tool.

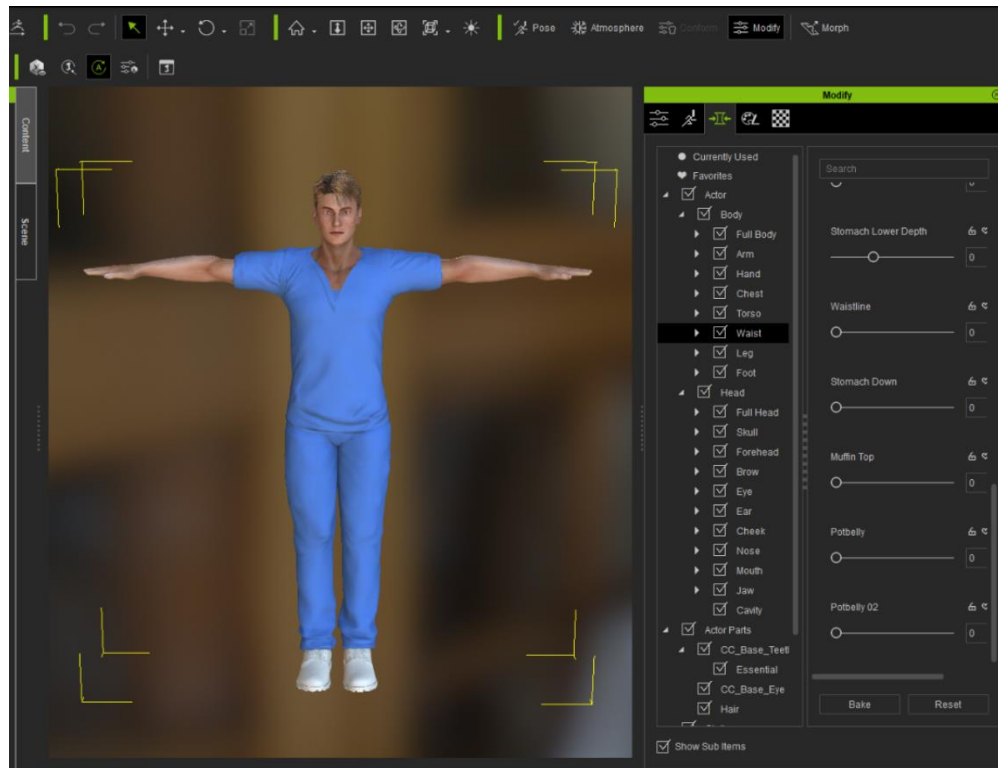


Figure 20: Customizing the avatar

Every character has its way of dressing to reflect his/her role. For example, the doctor cannot dress casually while on duty. When we go through the game, the patient is seen to be warmly dressed. It is only natural when a person is having the flu, she will feel cold and tries to dress warmly. When we compare Ebony to her friend Mary, we can clearly say that Mary is lightly dressed which shows that Ebony is the patient. The Social worker has a different way of dressing when compared to the doctor. A social worker doesn't dress up in scrubs.

The costumes of the characters also play an important role by showing what the profession of that character is. When the trainee is using this application for the first time, he/she might not always remember who she is seeing and might get confused. This visual cue provides trainee easy apprehension about the characters. For example, when the doctor is in the scrubs, it is very evident that it's the doctor that the trainee is currently watching.

Throughout our development, we have to run many iterations with extensive subjective assessment by testers to find the balance.

3.3. Facial Expressions

One of the most important features in animation for a virtual character is his/her facial expressions. Facial expressions are very important while a character is engaging in a conversation in order to make it appear more realistic. Eyes and lips are the main parts of the face that are required to create an expression. For example, happiness has wrinkles around the eyes, corners of the lips raised, muscles around the eyes become tight and the cheeks are raised.

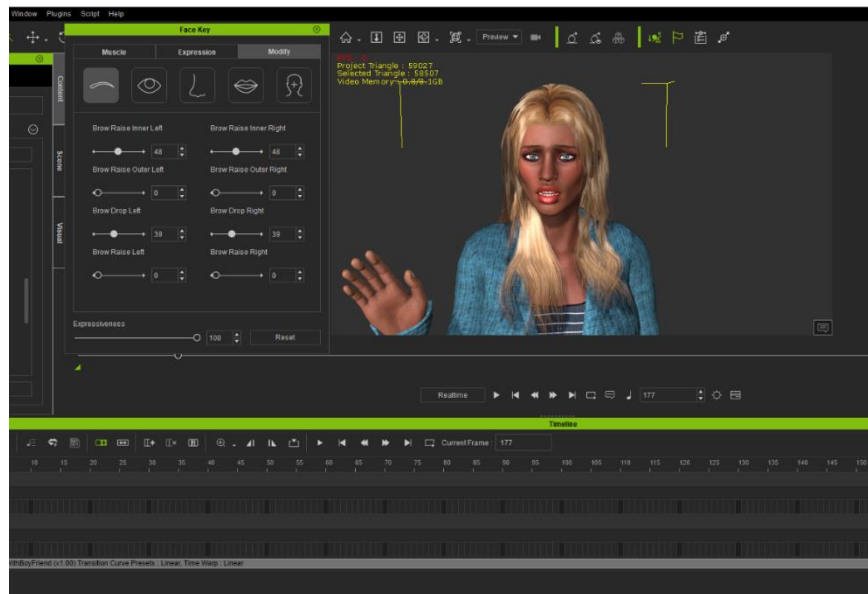


Figure 21: Facial Expressions

Combination of all these changes in the face, most importantly eyes and lips, make a person/character look happy.



Figure 22: Happiness

Similarly, making the character blink eyes will make the character look more real.

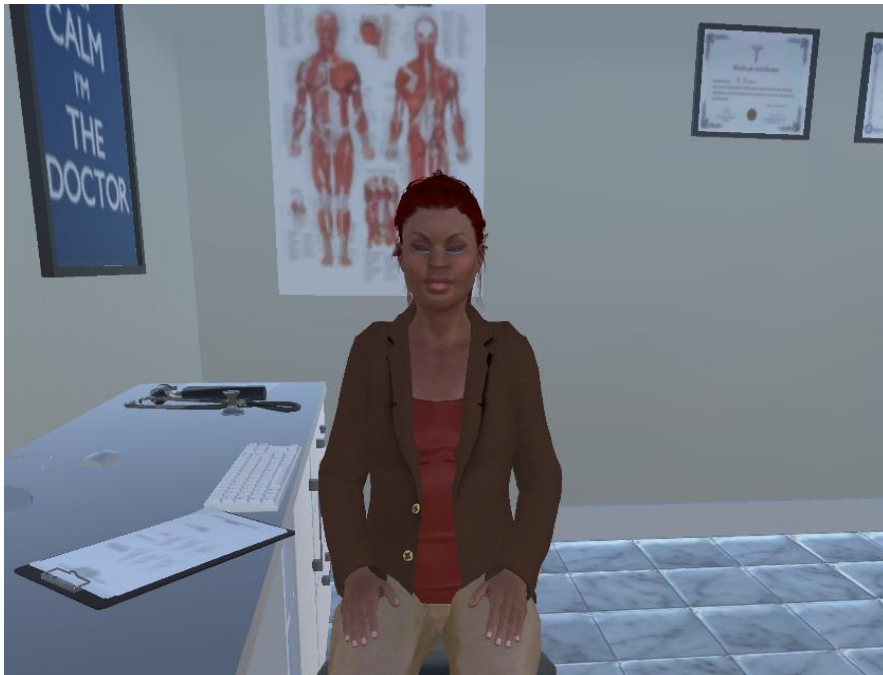


Figure 23: Blinking

3.4. Conversation and Interaction

Another important aspect that needs to be discussed is the voice when a character is speaking. There are two ways this can be done in game development.

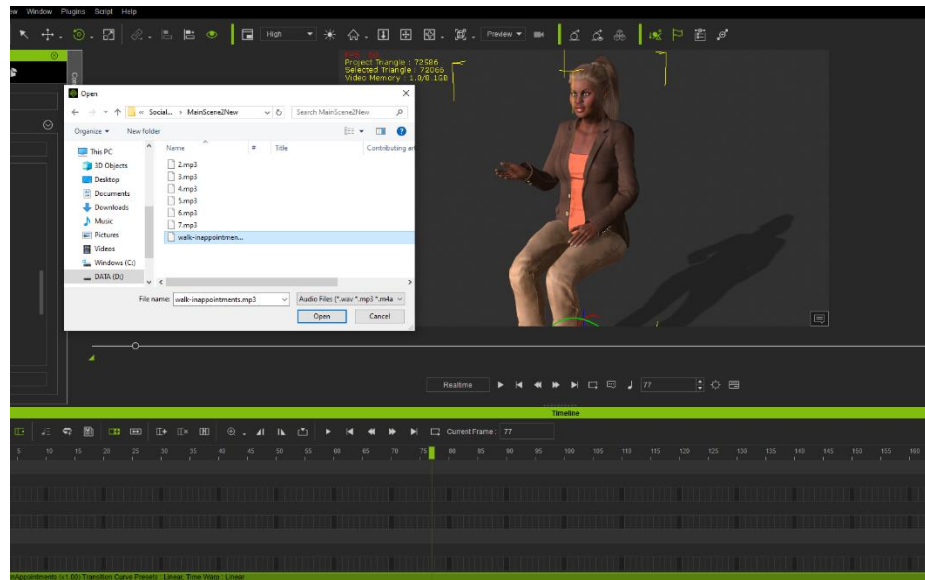


Figure 24: Adding voice to the animation

One is computer-generated voice recording, the other is actual human voice recording. There may be nothing wrong when the computer-generated voice recording is applied to the character in the game, but it might not seem as natural as a human voice recording sounds. This is particularly true for professional characters, such as receptionists, social workers, doctors and so on, as they are trained to speak with patients clearly and often using a gentle voice. The more natural a voice, the more it can convey through a game-based training. A human knows when to higher the pitch, when to lower. These fluctuations in the voice play a very important role in making people keep listening to what is

being spoken in the game just the same as in real life. This subtle but clear audio cues can reach across to the people, it will help people understand better about their conversations. In short, human voice recording reflect better professionalism in our work. Hence, the voices used in this game are human voice recordings from healthcare professionals. Every character has an individual voice. Hence, each character has a different individual's voice recorded.

Our project consists of conversations and interactions between different characters. When there is interaction, it is obvious that there will be some lip movement when the character is talking. Only when there is lip-movement we can understand who is speaking. Unfortunately, a simple character that is generated from the character creator cannot move its lips by itself according to the words. This needs a tool like IClone [10] for creating the apt lip-sync. There is a feature in IClone where we just write the script that we need the lip-sync for. Once the software reads the script, automatically IClone software creates the lip-sync according to the script after which we can make the animation of the movement of the body parts like hands, legs and other parts of the body.

When it comes to interaction between characters, in this game we have introduced patient view and doctor view. Patient view means the trainee is now playing the game from the perspective of the patient. For example, the patient is talking to the doctor. When we are in the patient's role, we will be able to watch a doctor talk to us/the patient.

3.5. Animation

When a person is talking or having a conversation with someone, it is very natural to do some hand gestures and head movement. For instance, Ebony, when she is waiting for her friend, Mary, will be found looking at herself in the mirror by touching her belly as she was doubtful, she might be pregnant. Showing the audience that Ebony is worried needs some delicate animation. This can be seen in Figure 5. Touching the belly has various meanings based on the way the belly is touched and the expression on the face.

In another instance, after talking to the receptionist, Ebony follows the male nurse and enters the exam room, where the male nurse sits in front of the EHR and

searches Ebony's information. To search the information on the computer, he will have to fill the required blanks for which he has to type. This typing should also be animated as the audience should know what he is doing. If ever the typing animation is not included, we won't even know what he is doing sitting in front of the computer.



Figure 25: Medical Assistant typing to check the details of Ebony

Eye contact is very important when talking to a person. Ebony is sad about things like breaking up with her boyfriend, using opioids for so long, etc. Engaging patient with eye contacts during conversation is designed as a part of this SDOH training. Showing these nuances in patient's response are very important for the

trainees of the healthcare services because these are of great help in relating the game to their real life. The challenges in all these cases are how to clearly show that Ebony is worried about her pregnancy, when Ebony does the eye contact with the doctor and when she does not, and what does she do when there is no eye contact from doctor, The above cases should be shown in a very limited time like each less than a minute.

The social worker is another character that we have designed in this game. She helps Ebony in finding the right health center for MAT. She has to call a few places to know which center the right fit for Ebony is. We can see in the game that she is calling places and talking to them about the dates, but it is compacted and there is no audio due to the time limit. Yet we can understand what is going on. This is achieved with the help of animation. A prop like the mobile phone is also used.

Without a mobile in her hand, the audience cannot understand what she is doing.



Figure 26: Social Worker talking on the phone

IClone is a tool that is used in this project to create any type of animation, lip-sync, etc.

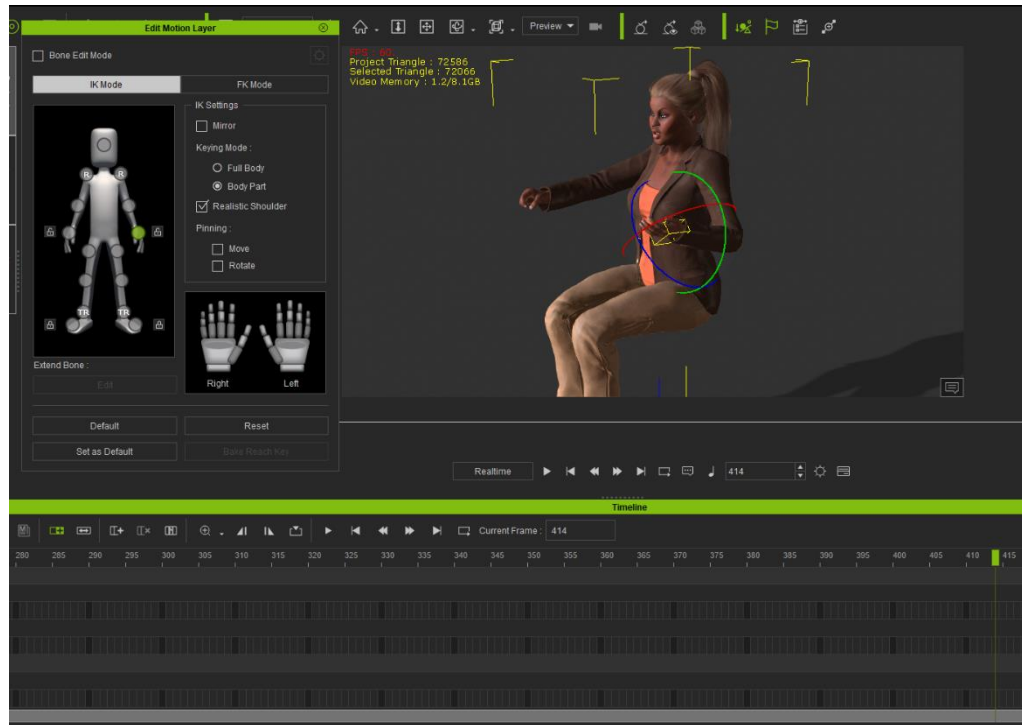


Figure 27: Adding the animation to the character

4. WORKFLOW FOR CREATING ANIMATED CHARACTERS

The first step is to create and optimize the characters. The process starts with the Character Creator tool. The order of creating the character is: 1) Customizing the body, clothes, and accessories; 2) Optimizing the mesh; and, 3) Exporting to IClone for further animation design.

The second step is about the creation of animation in IClone. The animation is required for facial expression, conversation and interaction, and other body motions. For instance, to produce the lip-sync for conversations, transcripts are uploaded (if any), to help create and align the lip movements. Lip movement is produced automatically when the transcript is uploaded. We also have the freedom to animate the lip movement manually. IClone has the feature of adding voice recordings so that we can create the animation accordingly. However, these voice recordings do not help produce lip movements automatically. Finally, according to the words and sentences, facial expressions and other body movements are manually animated. The animation is then exported to another tool, 3DXchange.

3DXchange, here, is used to change the file extension of the animation that has been created in the previous step. The output has .FBX as its file extension, such that it can be imported into Unity 3D. This becomes the third step.

The final step is importing the .FBX files into Unity 3D. After importing the animation, it is then rigged and then used in the storyline.

5. EXPERIMENTAL RESULTS

With a fully operational mobile game completed, we have carried out the preliminary validation study to prepare for future training sessions and further dissemination to the providers.

In order to assess the effectiveness of the game as a training tool for SDOH training, survey data are collected before and after the trainee taking the game-based training.

1. With respect to having this individual as my next patient, the amount of ANXIETY I feel is:

☐ 1. Low ☐ 2 ☐ 3 ☐ 4 ☐ 5. High

2. With respect to having this individual as a patient, the amount of FRUSTRATION that I feel is:

☐ 1. Low ☐ 2 ☐ 3 ☐ 4 ☐ 5. High

3. With respect to having this individual as a patient, the amount of COMPASSION that I feel is:

☐ 1. Low ☐ 2 ☐ 3 ☐ 4 ☐ 5. High

4. If given a choice, instead of this patient I would prefer to see a different patient for routine follow-up of a chronic health problem such as hypertension.

☐ 1. Strongly disagree ☐ 2 ☐ 3 ☐ 4 ☐ 5. Strongly agree

5. I expect that future encounters with this patient will be:

☐ 1. Easy ☐ 2 ☐ 3 ☐ 4 ☐ 5. Difficult

6. I believe that this patient is largely responsible for being in their current circumstances.

☐ 1. Strongly disagree ☐ 2 ☐ 3 ☐ 4 ☐ 5. Strongly agree

7. I believe that the circumstances in which this patient finds themselves are largely beyond their control.

☐ 1. Strongly disagree ☐ 2 ☐ 3 ☐ 4 ☐ 5. Strongly agree

8. I try to hide any negative thoughts about patients like this in order to avoid negative reactions from others.

☐ 1. Never ☐ 2 ☐ 3 ☐ 4 ☐ 5. Always

9. I attempt to act in nonprejudiced ways toward patients like this because it is personally important to me.

☐ 1. Never ☐ 2 ☐ 3 ☐ 4 ☐ 5. Always

Figure 28: Survey questions part 1

25. I believe going through this training experience will help me decrease any negative biases I may have toward patients like this.

☐ 1. Strongly disagree ☐ 2 ☐ 3 ☐ 4 ☐ 5. Strongly agree

26. I believe, going through this training experience will help me be a more understanding health professional.

☐ 1. Strongly disagree ☐ 2 ☐ 3 ☐ 4 ☐ 5. Strongly agree

27. This activity was an effective learning platform:

☐ 1. Strongly disagree ☐ 2 ☐ 3 ☐ 4 ☐ 5. Strongly agree

Figure 29: Survey questions part 2

Due to the time limitation of the thesis work, there is only a very limited number (three) of Medicaid professionals have gone through this simulation. The data are presented in Table 1 and Table 2. Table 1 first shows the providers' feedback after they completed the training. As shown in Table 1, all the participants strongly agree that this simulation is an effective learning platform that helps them: 1) decrease any negative biases toward patients like Ebony; and, 2) be a more understanding health professional.

Table 1: Effectiveness of the Simulation as a Learning Tool

	Q25	Q26	Q27
Post-Survey	5	5	5

We then compare the data between the pre-survey and post-survey. However, as shown in Table 2, it is difficult to have a conclusive analysis due to the limited data available, as the user responses show variations. We can still observe the following impacts of the training:

- On Q1: Two providers show high anxiety in pre-survey. This could be a result of the lack of encountering such a patient before. The training helps one of them lower their anxiety. The other provider has low anxiety to start with, but the anxiety jumps a scale level at the

completion of the training. This could be caused by the provider's more detailed comprehension of the patient.

- On Q2: The observation is similar to the Q1 on the frustration.
- On Q3: Here the result shows a significant increase of compassion toward the patient for one provider whose compassion starts low before the training.
- On Q7: Two providers show higher empathy toward the patient after the training.

Clearly, a more comprehensive validation trial is necessary to draw a conclusive assessment of the effectiveness of simulation. The project team is planning on carrying out such an investigation.

Table 2: Comparison between Pre- and Post- Survey

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
P1	Pre	5.0	5.0	2.0	4.0	5.0	4.0	2.0	5.0	4.0
	Post	5.0	5.0	5.0	4.0	5.0	4.0	3.0	4.0	4.0
P2	Pre	1.0	1.0	5.0	2.0	3.0	1.0	4.0	5.0	5.0
	Post	2.0	2.0	4.0	3.0	4.0	2.0	3.0	5.0	5.0
P3	Pre	5.0	2.0	5.0	3.0	4.0	1.0	3.0	2.0	5.0
	Post	4.0	1.0	5.0	3.0	2.0	1.0	4.0	2.0	5.0

6. CONCLUSION

This thesis research project has completed an immersion simulation-based training tool that helps raise the social determinants of health awareness among health care providers. We take advantage of the latest advances in mobile VR technologies to create a new SDOH training mobile game that is made available using tablets and smartphone devices. This way we can expose to the providers/doctors with realistic experience anytime and anywhere with an Internet connection.

In particular, this thesis has made significant contributions to the following prospects:

- It contributes to the development of the first mobile virtual immersion dedicated to SDOH training.
- It eliminates the limitation of availability and accessibility of current classroom lectures and/or role-play based SDOH education approach, such that providers have easy access to such training either as first-time learning or a refresh.

- It presents specifically such Social determinants of health as numerous adverse childhood experiences (ACEs), SUD, race and ethnicity, unemployment, and single mothers.
- Preliminary validation was carried out to assess its acceptance and effectiveness as a training tool. Early evidence from the data shows that this simulation is an effective learning platform that helps them: 1) decrease any negative biases toward patients like Ebony; and, 2) be a more understanding health professional.

Future work will start with a more comprehensive validation trial to draw conclusive assessment on the detailed effectiveness measurement of simulation. The project team is planning on carrying out such an investigation. Another future work will be the development of other cases to reflect a different set or combination of SDOH.

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